Alumina coated PtGa based catalysts for propane dehydrogenation

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The propane dehydrogenation reaction is generally catalyzed by Pt-based catalysts[1], usually promoted with a second metal such as Ga, Sn, In, etc. in order to improve activity, selectivity and resistance to coke formation[2]. Although significant improvements are achieved with the addition of a promoter and subsequent alloying to form a bimetal, the latter still suffers from coke formation and sintering. Regeneration of the catalysts is usually achieved by combustion of the coke by O_2. Alternatively, CO_2 can be employed as a mild oxidizing agent.

In order to stabilize the bimetallic nanoparticles against sintering, an advanced strategy is used which involves applying an Al_2O_3 coating layer over the PtGa/$MgAl_2O_4$ & Pt/Mg(Ga)(Al)O catalyst by Atomic Layer Deposition (ALD), a powerful tool for controlled modifications of solid surfaces. In the present work, a coating of 1nm was applied (coated catalyst).

This coating is calcined under inert atmosphere (N_2) to crack the layer in order to make it porous. Following this, the catalyst is subjected to a REDOX cycling process involving CO_2/H_2 (4 cycles) and O_2/H_2 (2 cycles), that imitates the industrial reaction/ regeneration step. The same set of experiments was performed for a catalyst without coating of Al_2O_3 (uncoated catalyst).

Investigation of the catalysts (coated & uncoated) for initial activity to propane dehydrogenation was performed and revealed higher conversion for the uncoated catalyst, which indicates that the coating is blocking some active sites.

In situ XAS (X-ray absorption spectroscopy) and SAXS (small angle X-ray scattering) are engaged in parallel (simultaneous measurement) during H_2-TPR, CO_2-TPO and a REDOX cycling process. SAXS is used to follow the evolution of the particle size. XAS gives a detailed structural and electronic information. The combination of these techniques is a necessity as the PtGa particles are very small (<3nm) and hence difficult to characterize using other techniques. A comparison is made between the coated and uncoated catalyst. Based on modelling of the SAXS spectra, the uncoated catalyst shows larger variation of its particle size upon each treatment, which indicates that the Al_2O_3 coating makes the catalyst more stable.

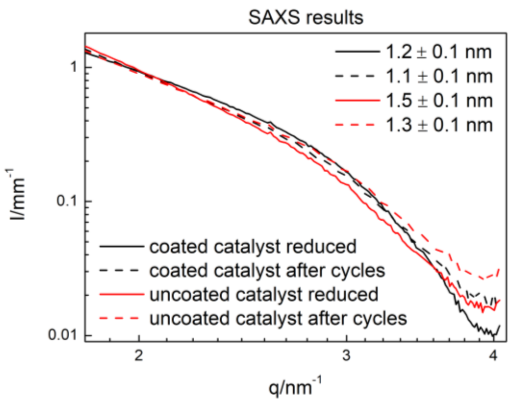

***Figure 1** SAXS results for reduced state and after cycles for PtGa/$MgAl_2O_4$ catalysts with the particle sizes obtained from SAXS modelling with their 95% confidence interval.*

References

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